# Quantization of Gravitational System and its Cosmological Consequences

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**Abstract**

We have found that the hierarchial problems appearing in cosmology is a manifestation of the quantum nature of the universe. The universe is still described by the same formulae that once hold at Planck's time. The universe is found to be governed by the Machian equation, $GM = Rc^2$, where $M$ and $R$ are mass and radius of the universe. A Planck's constant for different cosmic scales is provided. The status of the universe at different stages is shown to be described in terms of the fundamental constants (eg. $c, \hbar, G, \Lambda, H$) only. The concept of maximal (minimal) acceleration, power, temperature, etc., is introduced and justified. The electromagnetic interactions are shown to be active at a cosmic level. Their contribution would exclude the inclusion of dark energy in cosmology.

**Key Words**: Cosmology: early universe, cosmological parameters, quantum gravity

## 1 Introduction

Einstein added the cosmological constant to his general relativity equations in an attempt to get a gravitationally stable universe. When he later knew that the universe is expanding dropped his constant and regretted its addition. Cosmologists and particle physics have found that this term is connected with a constant vacuum (minimum) energy of the spate-time [1, 2, 3]. The value of this minimum energy is estimated to be very large in the early universe. However, at the present time the value of this constant is found to be vanishingly small. This contradiction is now coined in the

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term “cosmological constat problem”. To solve this problem several models [1,2, 3, 4] are proposed. Some models considered this constant to decay with time (or scale factor) [5, 6, 7]. These models are now known as vacuum decaying models. Others relate this to the energy density of some scalar field dominating the universe at early times having some properties that gives the present observed value. Scientists have been looking for some symmetry to set it to zero. In some supersymmetry models [4] it cancels but when the supersymmetry is broken to give the present universe its value becomes non-zero.

In fact, the present unresolved problems in cosmology has to do with the non-existence of a complete quantum gravity which blends general relativity with quantum mechanics. There are however, some hopes in the string theory to come up with the final remedy. General relativity is successful in describing large scale structures (stars, galaxies, universe), while quantum mechanics is applicable to microscopic scale(atomic). However, when quantum mechanics applied to macroscopic objects it doomed with failure. It seems there is no intersection region in which both systems converge. There is however some cases in which quantum mechanics was successful when applicable to cosmic systems, e.g., black holes. Thus it might be still possible to apply such a method to other gravitational systems.

The point is that when people apply quantum mechanics to large scale systems, they use the same unit of quantization,i.e., the Planck's constant. In fact, Planck's constant is a measure of the precision in which physical quantities in quantum mechanics can be distinguished. A microscopic system has an angular momentum of the order of Planck's constant. But one does not expect, for instance, a Sun to have such a small value. Therefore, one does not anticipate that this value to be so small for a macroscopic system. Contrarily, one would expect a macroscopic system to have a characteristics unit of quantization (a cosmic Planck's constant) that is so huge. For instance, the spin angular momentum of the Earth is $\sim 10^{34}$Js.

We know that a quantum formula approximates to the classical counterpart when $\hbar \to 0$. However, we do see that in classical world the unit of angular momentum is so big, so we expect an analogous quantum formula for macroscopic system to hold when $\hbar \to \infty$ instead, while all other quantities scaled up (mass, distance, etc). Moreover, we argue that cosmic Planck's constant is not unique but assumes different values from one system to another. With this idea in mind, we have found that when appropriate arrangements are made, quantum mechanical formulae of microscopic system apply equally well to macroscopic system. One of the consequences of this conjuncture is

that evolution of black holes. It is remarkable that the Schwarzschild radius of a black hole emerges naturally from this conjecture of cosmic quantization; it corresponds to the Compton (or de Broglie) wave length defined in terms of this cosmic Planck's constant. As we know, when the dimension of a physical system becomes of the order of Compton (de Broglie) wavelength, quantum effects become prominent. We thus see that quantum mechanics can be applied to microscopic systems as well as macroscopic ones, i.e., from a very small scale to a very large scale. This formalism shares the concept of duality manifested by string theories[1]. We have found the cosmic Planck's constant ($\hbar_c$) is scaled as $\hbar_c \propto (\frac{1}{\hbar})^n$, for some $n$. Such a framework may be linked with some kind of a scale invariance of the theory of quantum gravity.

One is inclined to ask the question whether the condition $\hbar \to 0$ is the only way to go from quantum theory to the classical theory? Had we adopted another formalism of quantum mechanics, would it be possible for us to find a correspondence law in which $\hbar \to \infty$ gets us back the classical regime? Or would it be possible to have a classical formalism which allows us to go from classical to quantum world by setting, say Newton's constant $(G) \to 0$ ? In this circumstance, one will have a bi-pass joining classical and quantum pictures of the world. This will help us that whenever advances are made in classical world a quantum mechanical analogue has to be assumed. This may seem to be plausible owing to the similarity between gravity and electromagnetism. There might be some symmetry which can render this transformation successful. In such a case one would say that a quantum system has more than one classical limit. Or reversely, one can go from the classical system to a quantum system by applying the inverse transformation? If such a duality existed, the description of natural laws becomes more interesting. One asks a question that, will it be possible to go from gravitational system to electromagnetic system owing to the similarity of both system? Could one use the relation $e^2 = Gm^2$ ?; and using the known formulae of the electromagnetic system and apply it to the classical system. In this situation one finds that the fine structure constant $\alpha_E \to \alpha_G = \frac{Gm^2}{\hbar c}$, leading to $\alpha_E = \alpha_G$ (if one uses $m = m_{\text{Planck}} = 1.85 \times 10^{-6}\text{g}$)[2]. Hence, gravity gets unified with electromagnetism at Planck's time. However, according to our conjuncture of cosmic quantization, one finds for the whole universe (today) that $\alpha_G = 1$. That means that gravity becomes a strong force at large scale while the other forces should be compared with it. This would imply that at the cosmic level, electromagnetism and strong forces become weak in comparison with gravity. This is the opposite situation for nuclear (or atomic) interactions. Thus,

[1] See, J. Polchinski, Rev. Mod. Phys. 68 (1996) 1245

[2] We obtain this value from the relation $e^2 = Gm^2$ and substituting for $e$ its value in esu.

one can transform gravitational system from being very weak to be very strong. Such a similarity principle may hold between electromagnetic and gravitational system. Thus one sees that these points should be considered before a successful theory of quantum gravity being endeavored. If this works well, we should make some critical changes to our understanding of the physical laws describing our world. One would hope that string theory can provide such a mechanism (or a transformation) by finding a formalism that realizes this idea. If this is realized, then one would argue that the classical system is a real quantized system if correctly read.

A proper unification of all interactions should include the fundamental constants, representing the four basic interactions $(G, c, \hbar, \Lambda)$, in its premises. An appropriate combinations of these constants can provide a proper description of the anticipated unified interaction. We have found that these fundamental constants describe completely our universe, at all stages.

Such a prescription may help elucidate the way to a fully quantize gravity. Aided with this belief a lot of the cosmological problem can be alleviated, as we will see here. In this work we have seen that the present contribution of the vacuum energy in no longer a puzzle. This is because this vacuum energy evolves from Planck's (quantum) value to its present value as a result of the quantization of the cosmological parameters, and that our vacuum energy is described by the same formula which once applied at Planck's time. The only thing is that the parameters describing our universe become quantized.

The underling equations describing the universe stem from Mach's principle represented by the equation $GM = Rc^2$, where $M$ and $R$ are the mass and radius of the universe. We have found that the present state of the universe is indeed a manifestation of its quantum nature.

## 2 The model

The Planck's mass is defined as

$$m_{\rm P} = \sqrt{\frac{\hbar c}{G}}\ . \tag{1}$$

from which one can write

$$\hbar = \frac{G m_{\rm P}^2}{c}\ . \tag{2}$$

We assume here that for any stable bound gravitational (cosmic) system there exists a cosmic Planck's constant analogue defined as[3],

$$\hbar_c = \frac{GM_{\rm P}^2}{c}\ , \tag{3}$$

where $M_{\rm P}$ is the Planck's mass of the corresponding cosmic system. The vacuum (quantum) energy density due to quantum fluctuation is written, as shown by [8], to be

$$\rho^{\rm v} = \frac{\Lambda c^2}{8\pi G} = \frac{c^5}{G^2\hbar}, \tag{4}$$

and consequently one defines a cosmic vacuum density as

$$\rho_c^{\rm v} = \frac{c^5}{G^2\hbar_c}\ . \tag{5}$$

We obtain from eq.(4) the relation

$$\hbar = \frac{c^3}{G\Lambda}\ , \tag{6}$$

and for a cosmic system one proposes

$$\hbar_c = \frac{c^3}{G\Lambda_c}\ . \tag{7}$$

Moreover, from a dimensional point of view, one expects the cosmic Planck's constant to embody quantities having to do with gravity, (viz., $M_{\rm P}$, $G$ and $\Lambda_c$). Such a combination is manifested in the form

$$\hbar_c = \frac{G^{\frac{1}{2}} M_{\rm P}^{\frac{3}{2}}}{\Lambda_c^{\frac{1}{4}}}\ , \tag{8}$$

that is valid for a cosmic gravitationally bound system.

# 3 Cosmic and quantum correspondences

Eq.(1) can be used to eliminate any mass dependence in the physical quantities. Hence, one can describe our universe in terms of the fundamental constants $(G, c, \hbar, \Lambda)$ only. For such a case the physical laws become scale independent and hold for all systems; microscopic as well as macroscopic. It is worth to mention that relation

$$\hbar\ \Lambda = \hbar_c\ \Lambda_c = \frac{c^3}{G}\ , \ \text{or} \qquad \rho^v\ \hbar = \rho_c^v\ \hbar_c = \frac{c^5}{G^2} \tag{9}$$

[3]the subscript 'c' hereafter refers to the cosmic value of the quantity.

holds throughout the cosmic expansion. The quantity $\hbar\Lambda$ represents a rate of formation (creation) of mater. This rate, which is constant, is equal to $\sim 10^{35}$kg/s. With this rate the universe must have acquired its present mass ($\sim 10^{53}$ kg) during a time of $10^{17}$sec $= 10^{10}$years. This indeed coincides with the present condition of the universe. This is apparent from the fact that $\Lambda$ was so big in the beginning and decreased to a very small value today at the expense of creating our present universe. Thus any deviation from its value in the beginning and its present value, the present universe (with its current state of being) would not have been brought. Hence, a non-zero cosmological constant is needed for the genesis of the universe. We observe that we have used almost all of vacuum reserve and what is left would not be enough to have remarkable effect on cosmic expansion. And the cosmic acceleration which we have now observed can be interpreted as due to the fact that our universe is very critical and that if mass is generated, which counteracts the expansion, makes the universe to accelerate in order to maintain its critical status so that matter (gravity) should not overwhelm.

For a Machian universe one has

$$G\rho \sim H^2 \ , \tag{10}$$

with $H$ being the Hubble's constant. With the help of eq.(4), the above equation yields

$$\hbar \ H^2 = \hbar_c \ H_c^2 = \frac{c^5}{G} \ . \tag{11}$$

This represent the rate of transformation of energy (power). However, this rate is constant and should be considered as representing a maximal power, which does not depend on a particular system.

From a purely dimensional argument one can construct a quantum acceleration from the set of fundamental constants $(c, \hbar, G)$ of the form[4]

$$a = \left(\frac{c^7}{G\hbar}\right)^{\frac{1}{2}} \tag{12}$$

to be valid at Planck's time, and according to our hypothesis, an analogous acceleration of the form

$$a_c = \left(\frac{c^7}{G\hbar_c}\right)^{\frac{1}{2}} \tag{13}$$

[4] see ref. [17] for a different postulate.

to be valid at cosmic scale. Comparison between eqs.(9) and (11) shows that one can write the relation[5]

$$H^2 = c^2\Lambda \ , \tag{14}$$

so that eq.(12) takes the simple form

$$a = cH \ , \ \text{or} \qquad a = c^2\sqrt{\Lambda} \tag{15}$$

and eq.(13) thus becomes

$$a_c = cH_c \ , \ \text{or} \qquad a_c = c^2\sqrt{\Lambda_c} \tag{16}$$

Apparently, one can write this acceleration in different forms (involving $c, \hbar, G, \Lambda, H$ only) owing to the relationship between the different fundamental constants. We observe that at Planck's time the acceleration was very enormous amounting to $\sim 10^{51}$m s$^{-2}$, and then evolving to a vanishingly small value for the whole universe ($\hbar_c \sim 10^{87}$J sec) of $10^{-10}$m s$^{-2}$. A similar value of $a_c$ today is found by Milgrom[6] with a different argument. However, this appears in Milgrom theory as a surprise, but we provide here a natural justification. This acceleration is independent of the mass of the object and is a universal constant, which every body should manifest. It is a characteristic of the present era of cosmic evolution and has to do with the existence of the vacuum. We expect this acceleration to be prominent (and detectable) at the present time with the use of sophisticated tools. Thus, one would expect that our universe today will be filled with such a quantum relic(residue).

One asserts that our universe is having critical conditions at the time. Such conditions have to be satisfied at all stages. Thus our universe appears to exhibit its dynamic as it evolves from one state to another. The universe evolves so it satisfies its critical. This requires some conspiracy among the different constants making the universe viable. This conspiracy is the driving power for the universe. We thus remark that the universe has a maximal power, maximum rate of creation of matter, etc.

The enormous value of the present Planck's constant ($\sim 10^{87}$J s.) helps understand why the entropy of the present universe is so huge. So if we had set $\Lambda$ to zero then the universe would have become filled with radiation rather than with matter, as this implies $\hbar_c \to \infty$. Hence, this setting resolve the two (cosmological constant and entropy) problems simultaneously.

It is believed that the universe satisfies Mach's relation hat

$$GM = Rc^2 \ , \tag{17}$$

[5]The relation that $\Lambda \propto H^2$ is found to be interesting (Arbab, A.I., 2003, Class. Quantum Grav. **20**, 93)

[6]Milgrom, M, 1983, ApJ **270**, 365.

where $M$ and $R$ are the mass and radius of the universe, respectively. This principle is said to have played an important role in forming Einstein's general relativity. We see that in the evolving universe Planck's mass, Planck's constant, the cosmological and the gravitational constants must evolve with time to satisfy the beauty of the simplicity of our universe. As Albert Einstein said "The most incomprehensible thing about the universe it is comprehensible" is due to the fact that our universe is so simple.

## 4 Some numerical estimates

Eqs.(3), (5), (7), (8) and (17) are our basic equations for describing our universe. In order the universe to satisfy eq.(17) at all epochs, $R$ and $M$ has to evolve with time (from Planck's time to the present).

In a recent work, we have shown that for this relation to hold during the radiation epoch, one must have

$$G \propto t^2 \, , \qquad M \propto t^{-1} \, , \tag{18}$$

and

$$\Lambda \propto t^{-2} \, . \tag{19}$$

We observe that in the early universe the ordinary Planck's constant ($\hbar$) does not change with time in the early universe. For this reason the cosmic eqs.(2) and (3) are the same, i.e., $\hbar = \hbar_c$. By bound system we mean the stars, the galaxies and the universe. It has been shown that those system have definite cosmic Planck's constants. It is also shown that the cosmic Planck's mass of these bound systems (the galaxies and the present universe) are found to be $\sim 10^{68}$J.s and $\sim 10^{87}$J.s, respectively from different perspectives [9, 10, 11, 12]. It is also found by Capozziello *et al.* [13] that Planck's constant for stars is $\sim 10^{52}$ J. s. This would mean, according to eq.(3), that the Planck's mass for stars system is $M_{\rm P} \sim 10^{30}$ kg. White dwarf (WD) are gravitationally bound system having a mass of $1.6 \times 10^{30}$ kg and density of $1.5 \times 10^{9}$ kgm$^{-3}$ and extending over a distance of $10^7$m. We will see in a moment, with some scrutiny, that these characteristics coincide with our results if one takes for this system the above values (viz., $M_{\rm P} \sim 10^{30}$ kg and $\hbar_c \sim 10^{52}$ J s). We find from eq.(7) or (8) that $\Lambda_c \sim 10^{-17}$m$^{-2}$, which corresponds to a distance scale of $\sim 10^8$ m. Moreover, eq.(5) yields $\rho_v \sim 10^{10}$kgm$^{-3}$. We thus see the contribution of the vacuum energy density for such a system is comparable to the density for the white dwarf (in which quantum pressure takes over in stopping the overwhelming gravity).

We turn now to calculate the present vacuum energy density of the universe described by the cosmic numbers, i.e., $\hbar_c$ and $M_{\rm P}$. The present (denoted by '0') vacuum energy of the universe, according to eq.(5) will be

$$\rho_{\rm v}^0 \sim 10^{-29}\ {\rm g\ cm}^{-3}\ , \tag{20}$$

which is of the same order of magnitude of the presently observed density of the universe. The Compton wavelength of the universe is given by

$$\lambda_c = \frac{h_c}{Mc} \sim 10^{26}\quad {\rm m}, \tag{21}$$

which coincides with the present radius of the universe. This shows that our universe is indeed a quantum system. For instance, for a black hole the Schwarzschild radius ($R_s$) given by $R_s = \frac{2GM}{c^2}$. With the aid of eqs.(3) and (21) this is transformed into

$$R_s = \frac{h_c}{Mc}, \tag{22}$$

which implies that whenever the physical dimension of an object become of the order of Compton wavelength quantum effects become predominant. We thus conclude that the Schwarzschild radius is (or of the order of) the 'cosmic' Compton wavelength.
As we have conjectured before that there is a quantum nature associated with planets (namely the Earth) of the order of $10^{34}$ Js [14], one finds from eq.(7)

$$\Lambda_c \sim 10^{6}\quad {\rm m}^{-2}\ , \tag{23}$$

which corresponds to a millimeter scale, i.e., $\frac{1}{\sqrt{\Lambda_c}} \sim 10^{-3}$ m . This is nothing but the Schwarzschild radius for the Earth. We remark that eq.(13) is also consistent with eq.(8) if we wite it to give $\Lambda_c$.

In terms of the present cosmological constant one gets

$$\Lambda_0 = \frac{c^3}{\hbar_c G_0} \sim 10^{-52}{\rm m}^{-2}\ , \tag{24}$$

in comparison with the Planckian value

$$\Lambda_{\rm P} = \frac{c^3}{\hbar G_{\rm P}} \sim 10^{69}{\rm m}^{-2}\ , \tag{25}$$

where we have shown earlier that $G_{\rm P} = G_0$ [12]. In order to unify gravity with the other three forces, the gravitational constant has to be a running coupling constant, and during some time blows up to the scale of the other three forces. It is expected that gravity get unified at Planck's

time. But we have shown earlier that this is not the case [12]. We expected the real unification to hold at a rather lower energy scale.

We thus see that $\Lambda$ is a quantized parameter and its value for a gravitationally bound system can be determined. Therefore, one gets

$$\frac{\Lambda_0}{\Lambda_{\rm P}} \sim 10^{-120} \ . \tag{26}$$

We, therefore, should be surprised by the vanishingly small value of the cosmological constant at the present time which follows from eqs.(24) and (25). What has happened is that the universe is still describe by its same equations as before and the evolution of the universe has scaled up some quantifies and scaled down others. Notice that the speed of light remains constant during all expansion epochs of the universe.

We see from eq.(17) that the present radius of the universe should be

$$R_0 = \frac{G_0 M_0}{c^2} \sim 10^{26} \ \text{m} \ , \tag{27}$$

which matches the observed value. The same equation applies to Planck's length, namely

$$R_{\rm P} = \frac{G_{\rm P} M_{\rm P}}{c^2} \sim 10^{-35} \ \text{m} \ . \tag{28}$$

We thus see, the apparently complicated universe, how simple it is. This also shows that how fundamental eq.(17) is, in addition to how quantum our universe is.

De Sabbata and Sivaram [15] related the the temperature ($T$) to the curvature ($\kappa$) and showed that

$$T \propto \sqrt{\kappa} \quad \propto t^{-1} \ , \tag{29}$$

and a maximal curvature is given by

$$\kappa_{\rm max.} = \frac{c^3}{\hbar G} \tag{30}$$

This equation, when compared with eq.(6), yields

$$\Lambda \sim \kappa_{\rm max.} \ . \tag{31}$$

This result provides another meaning to the cosmological constant by relating it to the maximum curvature of the space-time. Hence, the present smallness of the universe is due to the near-flatness of our present universe. From eqs.(18), (19) and (30) we see that the vacuum energy

relaxes according to the Planck's law. Therefore, one must expect a vacuum background filling our universe at the present epoch having a temperature

$$T_{\rm P}^0 \sim 10^{-29}{\rm K} \ . \tag{32}$$

Thus, this fluid rolled from a very high value at Planck's time of with $10^{32}$K to $10^{-29}$K. This is manifested differently in the smallness of the present value of the cosmological constant describing this vacuum. Therefore, the cosmological constant problem is no longer a puzzle, but defines a physical that is related to the very nature of our universe. This small value defines a minimum temperature that any body can assume. We remark that in the present formalism the hierarchial nature of the universe is related very much to the quantum (Planckian) nature. It therefore finds it natural justification; not as has been justified by the anthropic principle, which often adopted by cosmologists. Moreover, the quantum states that the universe can occupy is finite, and those are characterized by these large cosmological numbers. Equation (32) can be read as representing the temperature of a quantum fluid relaxing toady and having such a temperature, or a mass of $10^{-65}$g. If one relates this mass to the mass of a long range mediator (possibly the graviton), then one would say that gravity has a limiting range and is not infinite, as has long been understood. Or alternatively, one may interpret this as that gravity is not transmitted at the speed of light (c)! One can arrive at eq.(32) by applying the relation

$$E = m_{\rm P}c^2 = kT \ , \tag{33}$$

where $k$ is the Boltzmann constant, as valid at Planck's time. Using eq.(1) one finds

$$T = \sqrt{\frac{c^5\hbar}{k^2G}} \ . \tag{34}$$

Using eq.(12) one obtains the relation

$$T = \frac{\hbar a}{ck} \ , \tag{35}$$

a relation connecting the maximal acceleration with the maximal temperature. Such a relation ($T = \frac{\hbar \ a}{2\pi ck}$) is proposed by Unruh [16] that quantum particles should emit thermal radiation when they are accelerated. According to this proposition a particle undergoing a constant acceleration would be embedded in a heat bath at a temperature given by the above equation.

Again, according to our hypothesis the equation

$$T_c = \frac{\hbar_c}{ck}a_c \ , \tag{36}$$

is valid for cosmic system. We see that eq.(34) yields the universal values

$$a_c \sim 10^{-10}\mathrm{m\ s}^{-2}, \qquad \mathrm{T_c} \sim 10^{-29}\mathrm{K}, \tag{37}$$

at the present time ($h_c \sim 10^{87}$Js), and eq.(35) yields

$$a \sim 10^{51}\mathrm{m\ s}^{-2}, \qquad \mathrm{T} \sim 10^{32}\mathrm{K}, \tag{38}$$

at Planck's time. These findings agree with the earlier values. We remark here that eq.(33) is the well known formula for the Hagedorn temperature for elementary particles like pions [18].

It has been shown by [19] that the maximal tension in general relativity leads to a relation with the strings tension (string coupling constant ($\alpha'$, or Regge slope parameter) given by[7]

$$\alpha' = \frac{G}{c^4}\ , \tag{39}$$

which is independent of $\hbar$. One, however, can further relate this to the maximal temperature by the relation

$$T = \frac{\sqrt{c\hbar}}{k}\frac{1}{\sqrt{\alpha'}}\ . \tag{40}$$

However, string theory introduces a temperature scale (known as Hagedorn temperature) given by [20]

$$T_{\mathrm{Hagedorn}} = \frac{\sqrt{c\hbar}}{4\pi k}\frac{1}{\sqrt{\alpha'}}\ . \tag{41}$$

Consequently one may incline to consider the Hagedorn temperature as representing a minimal (maximal) temperature. Once again, we will assume that the cosmic analogue of this equation to exist. We emphasize here the fact that our universe had maximal (or minimal) quantities when it was born and evolving into minimal (or maximal) quantities by now. This recalls one with some principle that the universe should respect. This is in essence the duality principle endowed and reflected by string theories. We have seen that the maximal temperature occurred at Planck's time and a minimal one at the present time. Similarly one can view the present universal Planck's constat ($\hbar_c$) as representing a maximal value for Planck's constant and $\hbar$ (the ordinary Planck's constant) as a minimal value for Planck's constant. The maximal acceleration occurred at Planck's time to be $\sim 10^{51}$m s$^{-2}$ and the minimal acceleration occurring at the present time. Despite these

[7]Since the maximal force is independent of $\hbar$ one is inclined to interpret this as that the maximum force in the universe can not come from any force except gravitational. This maximal force is the gravitational force exerted by the whole universe. It is a conserved quantity; its vale at Planck's time is same as to its value today.

dualities, which seems at odds, our physical formulae do respect it. It is worth mentioning that within this formalism one avoids the occurrence of singularities (at the beginning or at the end) in our universe.

For completeness we define the Planckian magnetic field density, electric field, inductance and capacitance as

$$B_{\rm Pl} = \left(\frac{c^5}{4\pi\epsilon_0\hbar G^2}\right)^{\frac{1}{2}} , \tag{42}$$

$$E_{\rm Pl} = \left(\frac{c^7}{4\pi\epsilon_0\hbar G^2}\right)^{\frac{1}{2}} , \tag{43}$$

$$L_{\rm Pl} = \frac{1}{4\pi\epsilon_0}\left(\frac{\hbar G}{c^7}\right)^{\frac{1}{2}} , \tag{44}$$

$$C_{\rm Pl} = 4\pi\epsilon_0\left(\frac{\hbar G^2}{c^3}\right)^{\frac{1}{2}} , \tag{45}$$

where $\epsilon_0$ is the permittivity of free space. According to our hypothesis the present (universal) values of the above quantities are

$$B_{\rm Pl} \sim 10^{-8}{\rm T},\ {\rm E}_{\rm Pl} \sim 1{\rm V/m},\ {\rm L}_{\rm Pl} \sim 10^{19}{\rm H},\ {\rm C}_{\rm Pl} \sim 10^{16}{\rm F}\ , \tag{46}$$

representing the relic (residue) values of the Planckian time. We remark that one can related the above quantities to Planck density and acceleration. We found, today, that the Planckian capacitance and inductance reach their maximal values, while the electric field and magnetic field density relax to their minimal values. If one calculate these values for galactic ($\hbar_c \sim 10^{68}$Js) and solar ($\hbar_c \sim 10^{52}$Js) levels, one respectively arrives at

$$B_{\rm Pl} \sim 10^{2}{\rm T},\ {\rm E}_{\rm Pl} \sim 10^{6}{\rm V/m},\ {\rm L}_{\rm Pl} \sim 10^{9}{\rm H},\ {\rm C}_{\rm Pl} \sim 10^{6}{\rm F}\ ; \tag{47}$$

and

$$B_{\rm Pl} \sim 10^{10}{\rm T},\ {\rm E}_{\rm Pl} \sim 10^{18}{\rm V/m},\ {\rm L}_{\rm Pl} \sim 10{\rm H},\ {\rm C}_{\rm Pl} \sim 10^{-2}{\rm F}\ . \tag{48}$$

If one believes in the gravitional-electrical symmetry we come up with the definition of a cosmic-magnetic moment defined as

$$\mu_B^c = \frac{q\hbar_c}{2M} \sim \sqrt{\left(\frac{G}{k}\right)}\ \hbar_c\ , \tag{49}$$

where we have used the gravitational charge ($q$) of a cosmic body as $kq^2 = GM^2$ (where $k = \frac{1}{4\pi\epsilon_0}$). With this prescription one reveals that the present universe has a cosmic magnetic moment $\sim$

$10^{68}$J/T so that it is now dominated by gravito-magnetic energy $E = \mu_B^c B_{\rm Pl} \sim 10^{78} \times 10^{-8} = 10^{70}$J. Since a galaxy has a gravito-magnetic moment of $\sim 10^{58}$J/T, one finds this gravito-magnetic energy to be $\sim 10^{60}$J. This would imply that the universe contains some $10^{11}$ galaxies. For the universe at Planck's time its magnetic moment would be $\sim 10^{-44}$J/T so that its gravito-magnetic energy should be $\sim 10^{9}$J.

With the same token, one defines the gravito-electric dipole moment as $\mu_E^c = qd = \sqrt{\left(\frac{G}{k}\right)}Md$, where $d$ is the distance between the dipoles. By virtue of this equation, the gravito-electric energy of the universe today would be $E = \mu_E^c E_{\rm Pl} = 10^{-10} \times 10^{53} \times 10^{26} \times 1 \sim 10^{70}$J. The gravito-electric energy of the universe at Planck's time would be $E = \mu_E^c E_{\rm Pl} = 10^{-10} \times 10^{-8} \times 10^{-35} \times 10^{61} \sim 10^{9}$J. These calculations give very consistent and reasonable values that are presently known to describe our universe. Apparently, the energy of the universe today is dominated equally by electromagnetic as well as gravitational interactions. Despite this fact no one today does think that such an electromagnetic contribution exist. This unseen contribution might solve the missing energy of the universe. Thus, the existence of dark energy (quintessence) that resolve this missing mass might not be necessary; it might be the second blunder that contemporary cosmologists have made after Einstein to justify the present cosmic acceleration! We thus see that the electromagnetic interactions are present even at cosmic level, but not apparent. They are embedded in gravity. We remark that an acceleration of an order of $10^{-10}$ $ms^{-2}$ can be interpreted as due to a unit mass of gravitational charge $q = \sqrt{4\pi\epsilon_0 G}$ moving in a residual electric field, as given by eq.(46). We notice this is the same as that obtained in eqs.(13) and (16). We would expect to come up with these quantities in our search at these cosmic levels outlined above. These relics (residues) should be found at the present time. Thus any experimental endeavor to find these *backgrounds* physical quantities will be very interesting.

The maximal and minimal cosmological quantities are summarize in table 1.

## Conclusion

We have seen that our universe is an indeed evolving quantum system. It is governed by the Mach relation and the vacuum (quantum) energy density that has been continually contributing to the total energy density of the universe. We have seen that the different mass scales we observe today is a manifestation of the quantum nature of our universe. Thus our universe is really quantum evolving system. This simple description outlined in this letter solves the cosmological constant

problems and the hierarchial problems upsetting our standard model of cosmology. The idea that our universe is a quantum system fits remarkably well with the present condition of the universe. We have shown that one can describe the status of the universe by a set of fundamental constants (eg., $c, \hbar, G, \Lambda, H$) only. This would require a cooperation (conspiracy) between these constants in order to satisfy this eternal picture of our universe. We believe that present description of the universe we postulated, allows for a conformal representing of the basic laws underlying these formalism. This is because we have not considered any mass scale in our basic equations. This makes our universe looks quite simple and understandable. We remark that the present formalism, albeit non-formal, it shed a lot of lights on the real formulation of quantum gravity that every one awaits its advent. We have provided a semi-quantum approximation for a classical system. universe. By writing our basic formulae of the universe in terms of the fundamental constants $(c, \hbar, G, \Lambda, H)$, we have in principle considered a unification of all interactions (relativity, quantum, gravity, vacuum and cosmology), but in a rather non formal approach. Though our treatment of quantization of gravitational system is crude it however gives a flavor of the subject. Within this framework all phenomena appearing in the universe can be seen as a realization of this unification. We believe that a real quantization of gravity should include the electromagnetic interactions that are present even at cosmic level.

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Table 1: The values (in order of magnitudes) of the maximal and minimal physical quantities in the universe

| Planckian quantity | Unit | Maximal value | Minimal value |
|---|---|---|---|
| Planck's constant | J s | $10^{87}$ | $10^{-34}$ |
| Acceleration | m s$^{-2}$ | $10^{51}$ | $10^{-10}$ |
| Mass | kg | $10^{53}$ | $10^{-8}$ |
| Time | sec | $10^{17}$ | $10^{-44}$ |
| Density | kg m$^{-3}$ | $10^{96}$ | $10^{-26}$ |
| Temperature | K | $10^{32}$ | $10^{-29}$ |
| Cosmological constant | m$^{-2}$ | $10^{69}$ | $10^{-52}$ |
| Inductance | H | $10^{19}$ | $10^{-42}$ |
| Capacitance | F | $10^{16}$ | $10^{-45}$ |
| Electric field | V/m | $10^{61}$ | $10^{0}$ |
| Magnetic field density | T | $10^{53}$ | $10^{-8}$ |

We observe that these quantities are either 61 or 122 orders of magnitude when compared between Planck era and today! Without these finetunings our universe would not have remained for billion years.